RESTORATION ADVISORY BOARD

Little America

June 22, 2004

AGENDA

- Introduction
- Approval of Minutes May 18, 2004
- Discussion/Questions on Environmental Restoration Project Status
- Hydraulic Fracturing Technology Presentation
- Meeting Logistics
  - Future Meeting Schedules
  - Next Meeting: August 24, 2004 at Little America
- Adjournment

APPROVAL OF MINUTES

May 18, 2004

Meeting

Discussion/Questions on Environmental Restoration Project Status

Utilization of Enabling Technologies such as Hydraulic Fracturing to Enhance the Permeation/Dispersal of Permanganate during *In Situ* Chemical Oxidation (ISCO)

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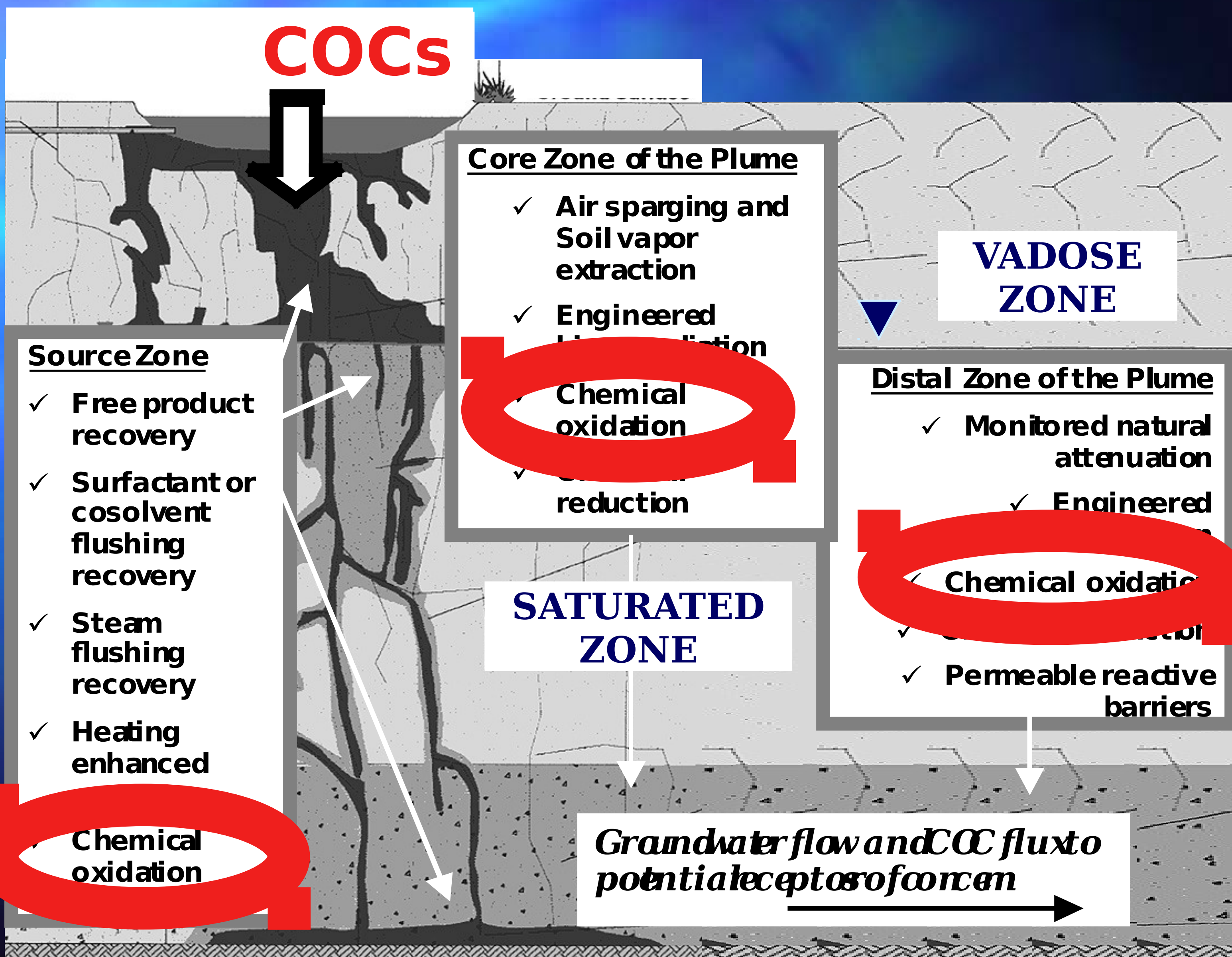
In Situ Chemical Oxidation (ISCO)

COCs

- TCE
- PCE
- DCE
- VC
- BTEX
- PAHs
- Phenols
- PCP
- PCBs
- Cresol
- Diesel fuel
- MTBE
- Dieldrin
- HMX, RDX
- TNT
- .....



In Situ Chemical Oxidation

During the early 1990’s, experiments and pilot tests demonstrated the potential viability of chemical oxidation for in situ remediation.

Applications now include:

- H_2O_2 (Fenton’s reagent)
- $KMnO_4$ or $NaMnO_4$
- O_3

Other Oxidants:

- Persulfate
- Peracetic Acid
- Hypochlorous acid

In Situ Chemical Oxidation with Permanganate

Potential Benefits:

- Reaction kinetics are rapid.
- Can degrade many contaminants of concern (COCs).
- Can increase the rate of DNAPL interface mass transfer.
- Possible process-induced beneficial effects.
- Can be used to augment existing treatment systems.
- Available in liquid and solid forms

In Situ Chemical Oxidation with Permanganate

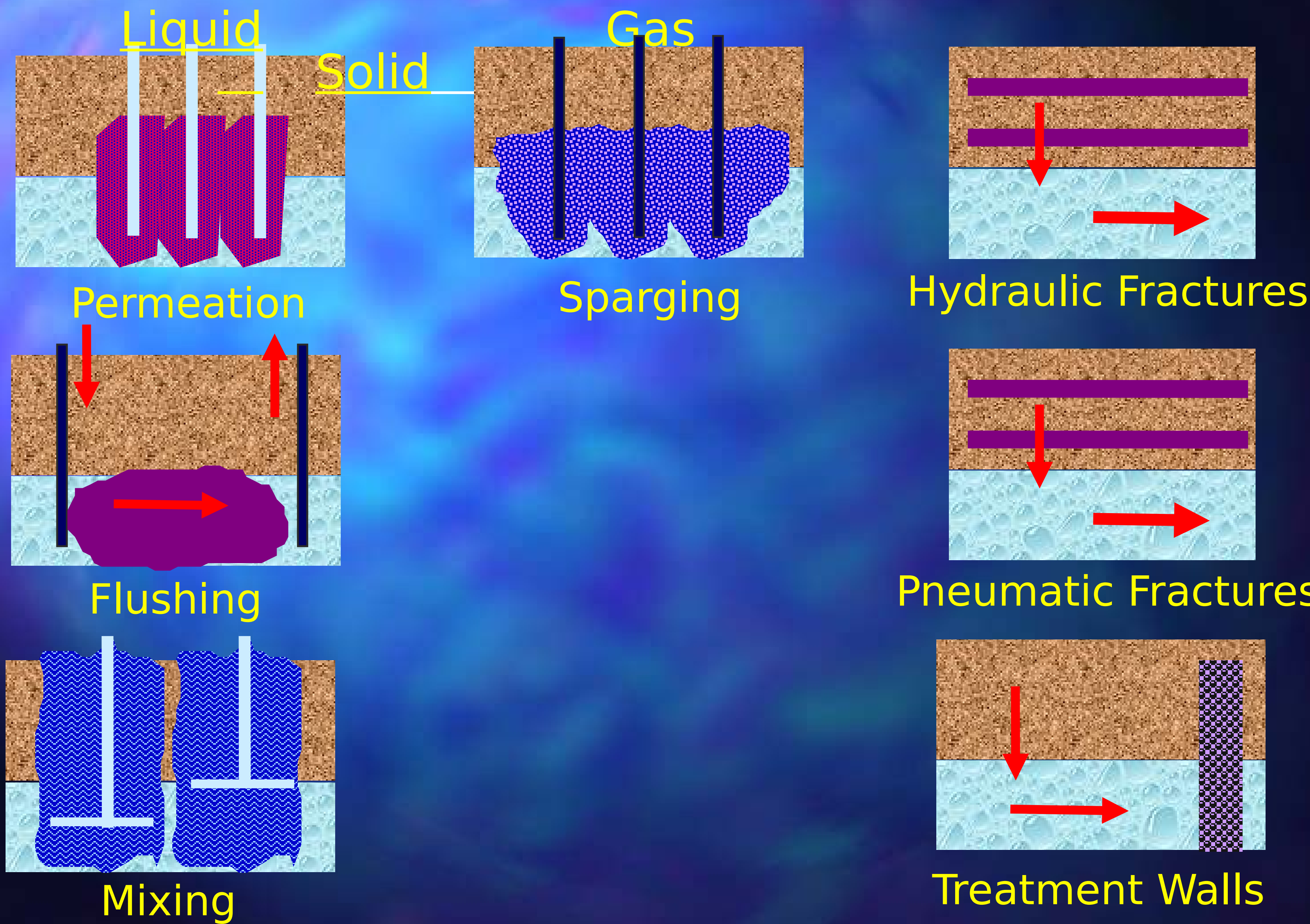
Potential Limitations:

- Possible process-induced detrimental effects
- Subsurface oxidant distribution can be difficult; as a result, high treatment efficiency is not always possible

Oxidant Type/Form

Feature	Fenton's	Ozone	Permanganate
Reagent:	Liquid, offsite	Gas, onsite	Liquid/solid, offsite
Dose:	5 to 50 wt.%	Variable	0.02 to 4.0 wt.%
Amendments:	Fe, acid	Often air	None typically
COCs (+):	BTEX, PAHs, phenols, alkenes	BTEX, PAHs, phenols, alkenes	PAHs, phenols, alkenes
COCs (-):	PCBs	PCBs	Alkanes, PCBs
Delivery:	Injection wells	Sparge wells	Injection wells, fractures
Distribution:	Advection	Advection	Advection/Diffusion
Reaction rate:	Very high	High - Moderate	High - Moderate

Delivery Systems



Geologic/Hydrologic Site Characteristics

Subsurface heterogeneities

- Preferential flow

Permeability

- Low Permeability versus high permeability

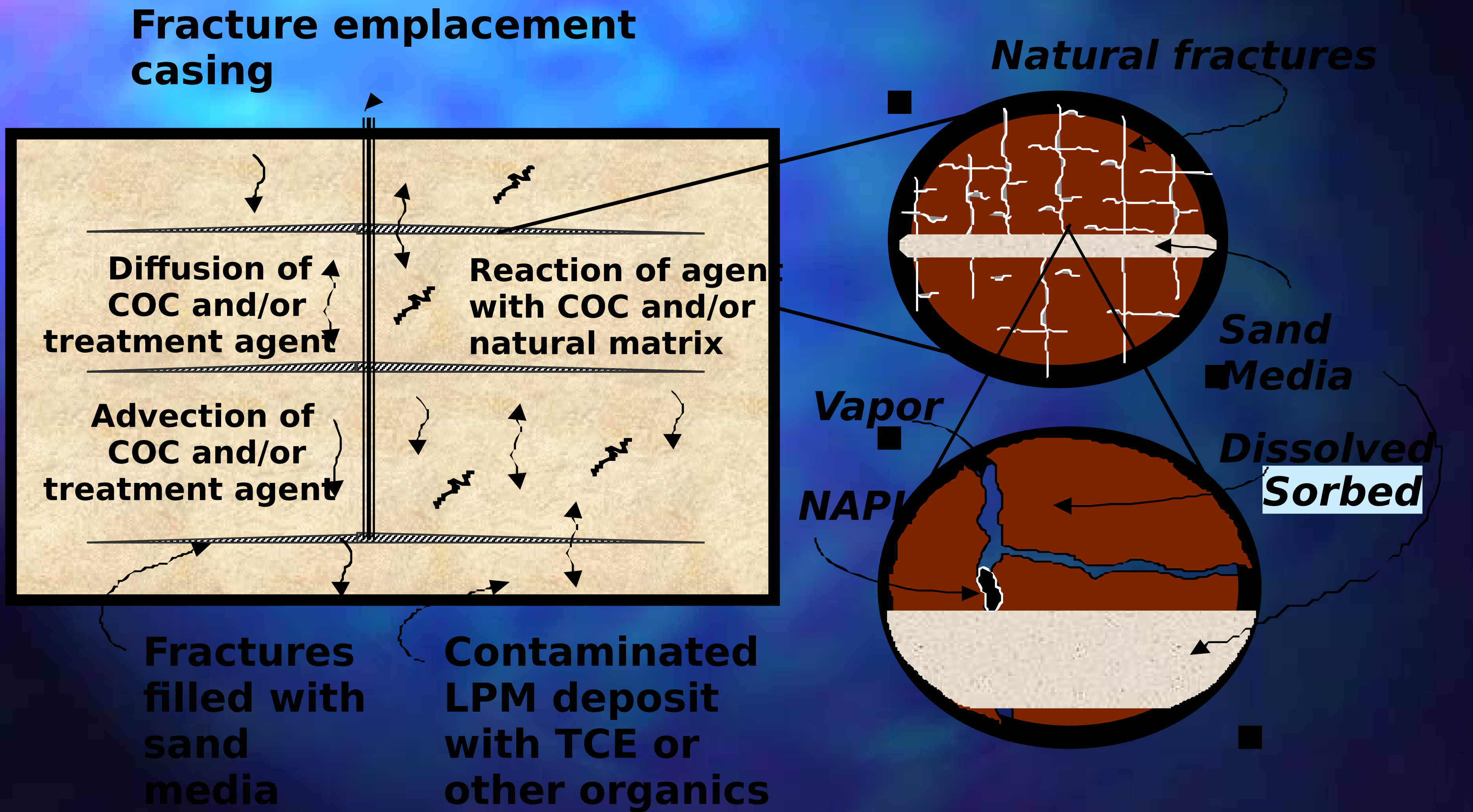
Natural oxidant demand (NOD)

- High NOD versus low NOD

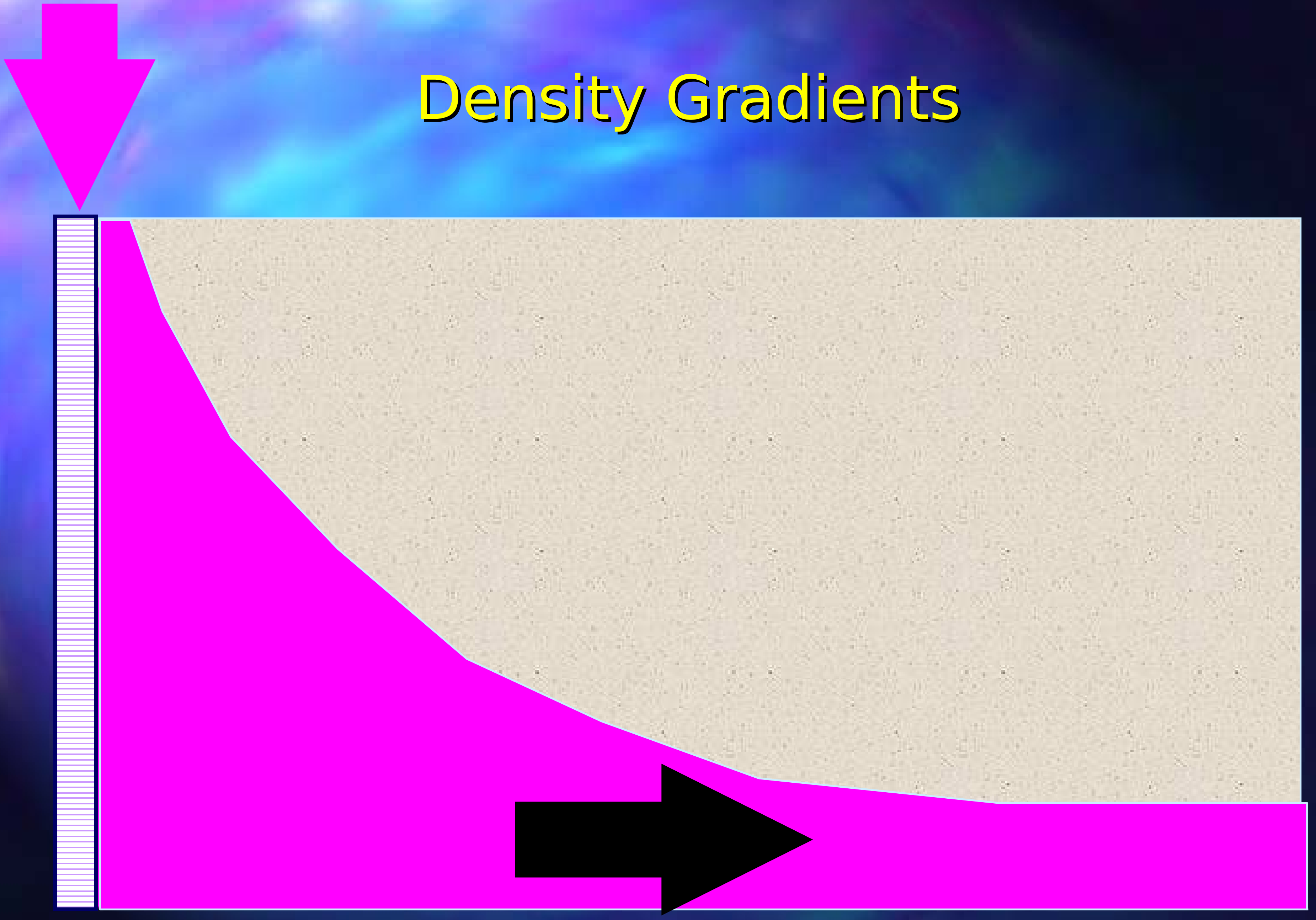
Transport Limitations

Hydraulic Fracturing

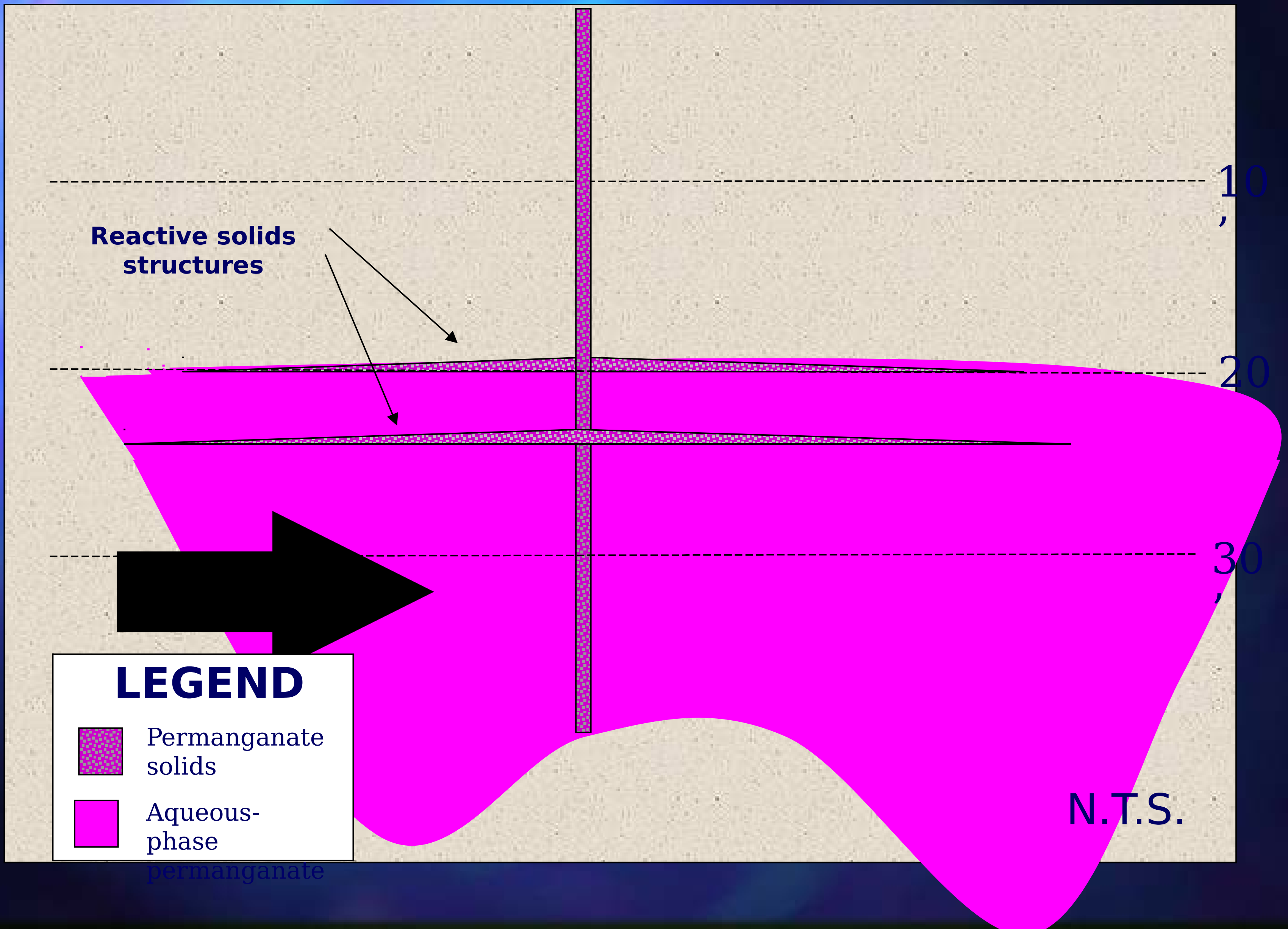
Hydraulic Fracturing



Density Gradients



Hydraulic Fracturing with Permanganate



Fracture Emplacement

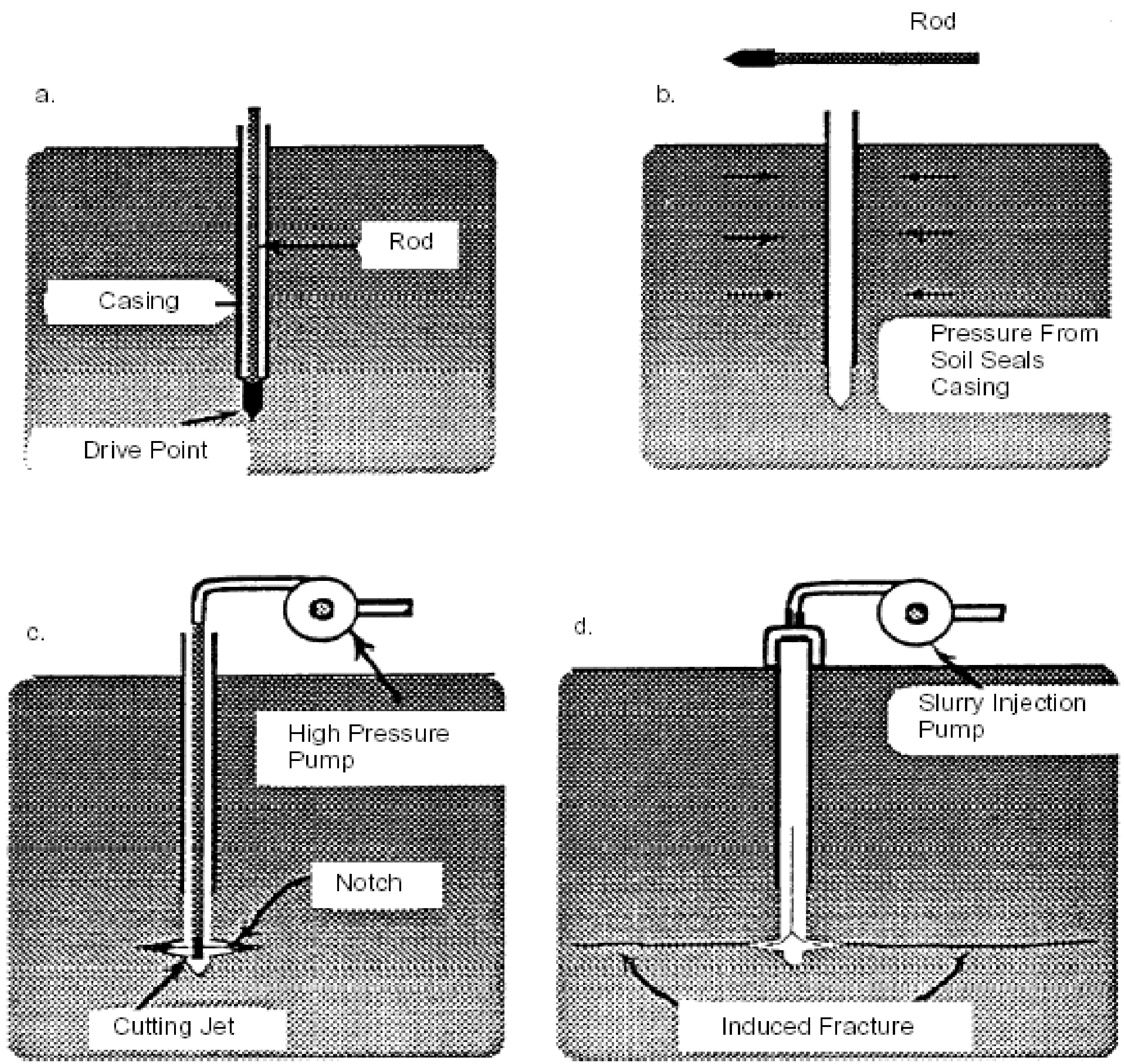


Figure. 3-6. Fractures created at the bottom of driven casing.

Case Study Results

TABLE 2. Test Cell Installation Features

Test cell characteristic (1)	Units (2)	Iron-filled fractures for declorination (3)	Permanganate-filled fractures for oxidation (4)
Method and time of installation	—	Iron metal and guar gel; 2–3 hr	Permanganate OPM; 2–3 hr
Fracture depth–proppant–amount	—	1.2 m–Sand–0.14 m^3 1.8 m–Fe^0–1,000 kg 2.4 m–Fe^0–3,000 kg 3.6 m–Fe^0–2,600 kg 5.0 m–Sand–0.57 m^3	1.2 m–Sand–0.14 m^3 1.8 m–$KMnO_4$–400 kg 2.4 m–$KMnO_4$–600 kg 3.6 m–$KMnO_4$–600 kg 5.0 m–Sand–0.57 m^3
Test cell diameter	m	6	6
Test cell depth	m	5	5
Test cell volume	m^3	148	148
Fracture trend direction	—	SE	NW
Fracture propagation	—	Typical	Typical

Case Study Results

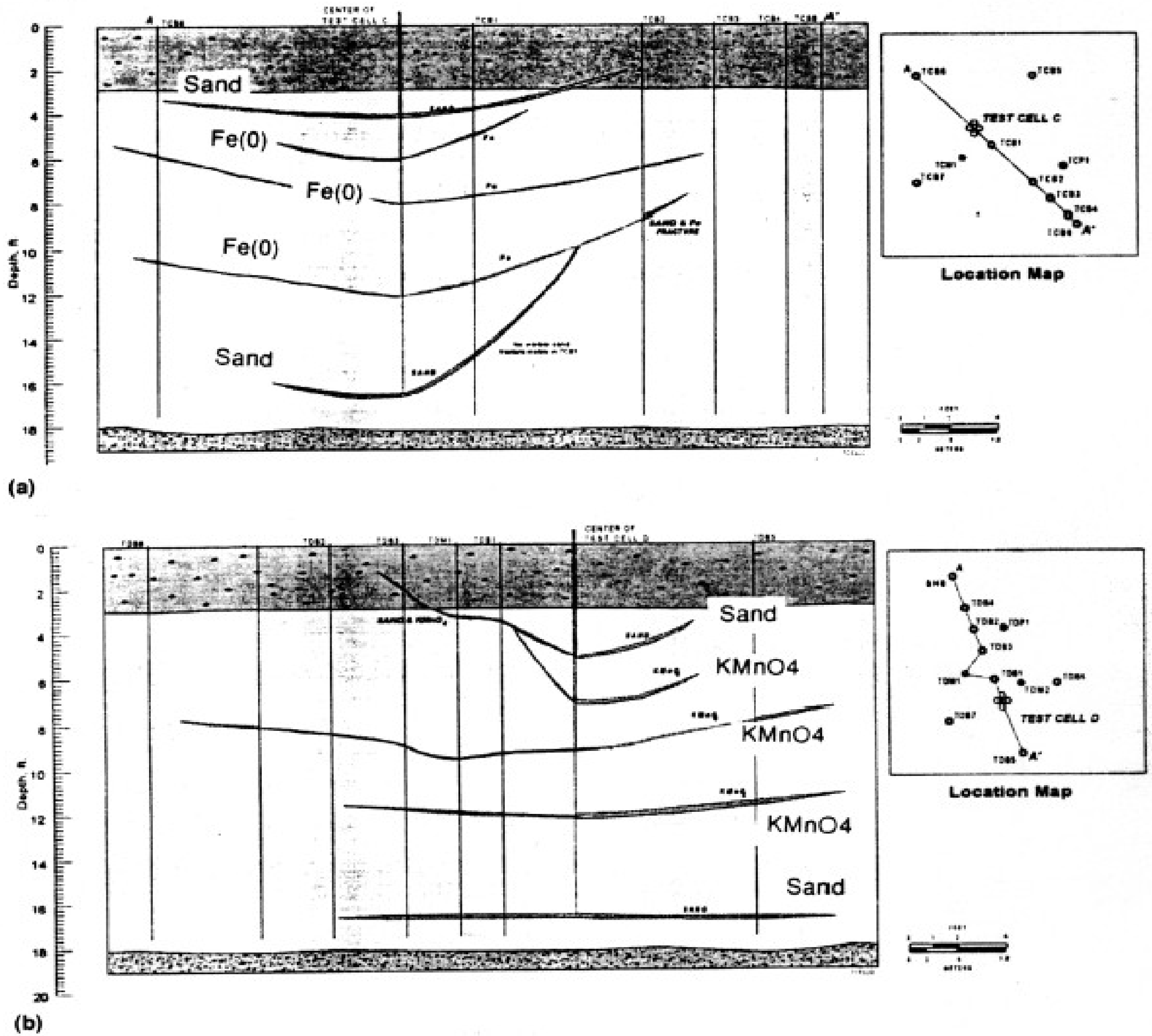
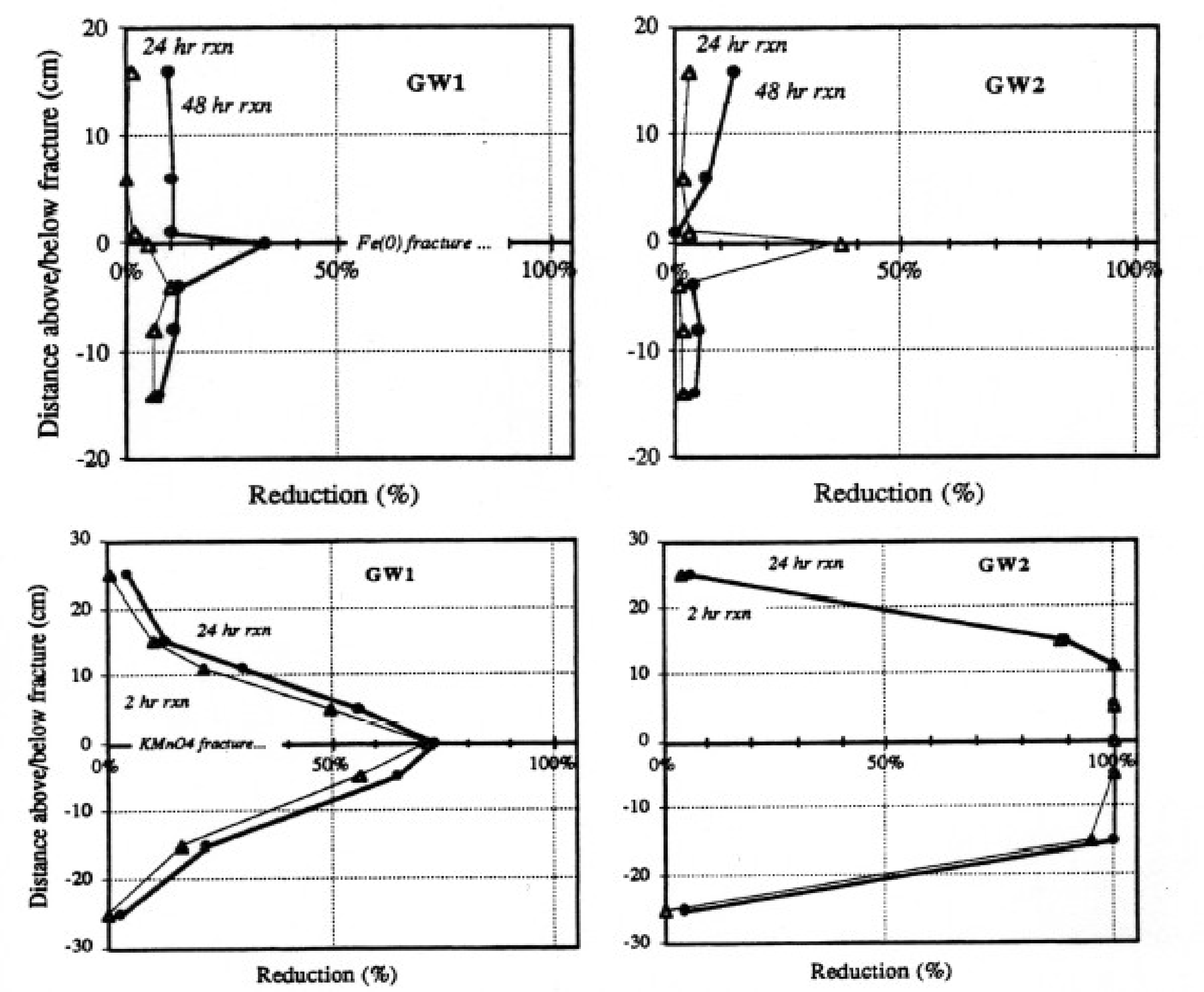
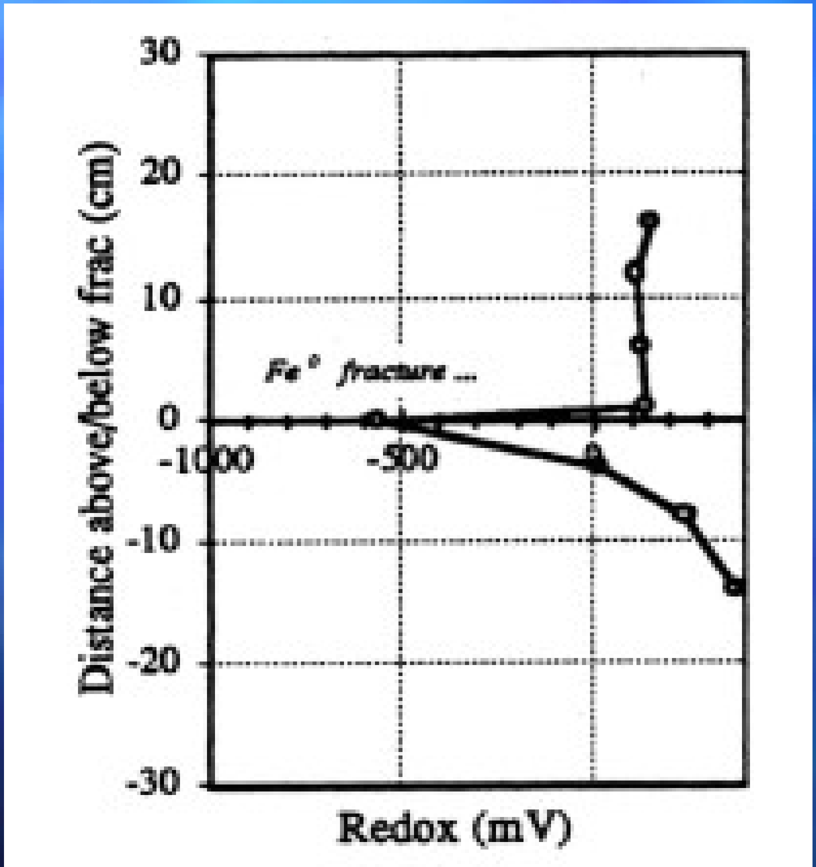


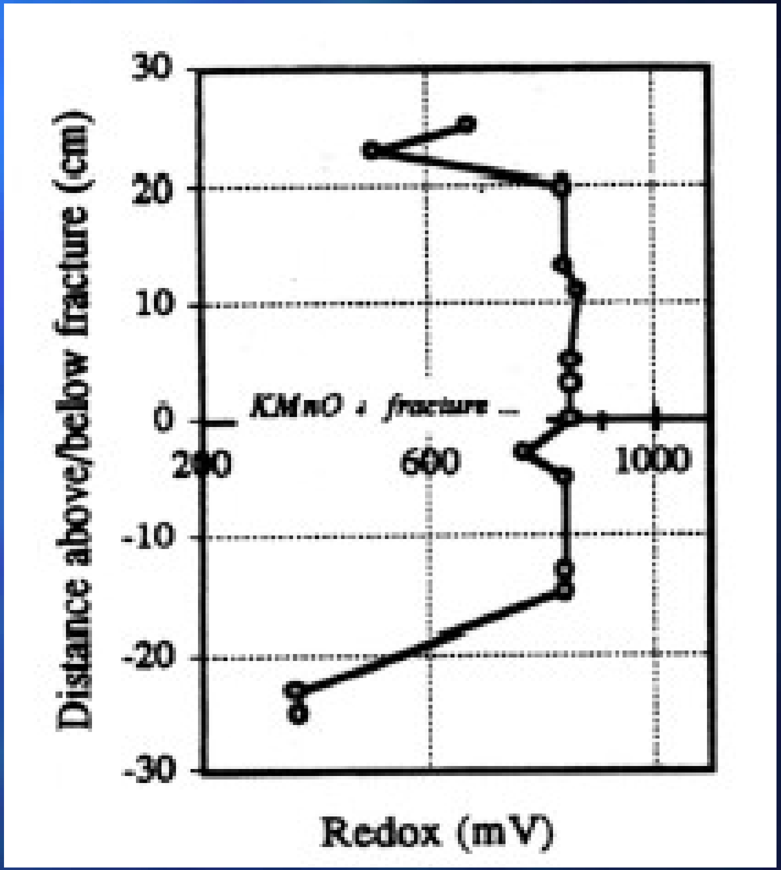
FIG. 3. Cross Sections of Test Cells Used to Evaluate: (a) Fe^0 Metal; (b) $KMnO_4$ OPM Filled Hydraulic Fractures as Horizontal Treatment Zones

Case Study Results



Case Study Results





Case Study Results

MEETING LOGISTICS

August 24, 2004

Little America

ADJOURNMENT